

Embedded Systems

Introduction to Computing

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Decimal to Binary Conversion

Example 0-1

Convert 25_{10} to binary.

Solution:

	<i>Quotient</i>	<i>Remainder</i>	
$25/2 =$	12	1	LSB (least significant bit)
$12/2 =$	6	0	
$6/2 =$	3	0	
$3/2 =$	1	1	
$1/2 =$	0	1	MSB (most significant bit)

Therefore, $25_{10} = 11001_2$.

Binary to Decimal Conversion

Example 0-2

Convert 11001_2 to decimal.

Solution:

Weight:	16	8	4	2	1
Digits:	1	1	0	0	1
Sum:	$16 +$	$8 +$	$0 +$	$0 +$	$1 = 25_{10}$

Example 0-3

Use the concept of weight to convert 39_{10} to binary.

Solution:

Weight:	32	16	8	4	2	1
	1	0	0	1	1	1
	$32 +$	$0 +$	$0 +$	$4 +$	$2 +$	$1 = 39$

Therefore, $39_{10} = 100111_2$.

Hexadecimal Systems

Example 0-4

Represent binary 100111110101 in hex.

Solution:

First the number is grouped into sets of 4 bits: 1001 1111 0101.
Then each group of 4 bits is replaced with its hex equivalent:

1001	1111	0101
9	F	5

Therefore, $100111110101_2 = 9F5$ hexadecimal.

Example 0-5

Convert hex 29B to binary.

Solution:

	2	9	B
29B	=	0010	1001 1011

Dropping the leading zeros gives 1010011011.

**Table 0-1: Base 16
Number System**

Decimal	Binary	Hex
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

Decimal to Hex Conversion

Example 0-6

(a) Convert 45_{10} to hex.

<u>32</u>	<u>16</u>	<u>8</u>	<u>4</u>	<u>2</u>	<u>1</u>	First, convert to binary. $32 + 8 + 4 + 1 = 45$
1	0	1	1	0	1	

$$45_{10} = 0010\ 1101_2 = 2D\ \text{hex}$$

(b) Convert 629_{10} to hex.

<u>512</u>	<u>256</u>	<u>128</u>	<u>64</u>	<u>32</u>	<u>16</u>	<u>8</u>	<u>4</u>	<u>2</u>	<u>1</u>
1	0	0	1	1	1	0	1	0	1

$$629_{10} = (512 + 64 + 32 + 16 + 4 + 1) = 0010\ 0111\ 0101_2 = 275\ \text{hex}$$

(c) Convert 1714_{10} to hex.

<u>1024</u>	<u>512</u>	<u>256</u>	<u>128</u>	<u>64</u>	<u>32</u>	<u>16</u>	<u>8</u>	<u>4</u>	<u>2</u>	<u>1</u>
1	1	0	1	0	1	1	0	0	1	0

$$1714_{10} = (1024 + 512 + 128 + 32 + 16 + 2) = 0110\ 1011\ 0010_2 = 6B2\ \text{hex}$$

Hex to Decimal Conversion

Example 0-7

Convert the following hexadecimal numbers to decimal.

(a) $6B2_{16} = 0110\ 1011\ 0010_2$

<u>1024</u>	<u>512</u>	<u>256</u>	<u>128</u>	<u>64</u>	<u>32</u>	<u>16</u>	<u>8</u>	<u>4</u>	<u>2</u>	<u>1</u>
1	1	0	1	0	1	1	0	0	1	0

$$1024 + 512 + 128 + 32 + 16 + 2 = 1714_{10}$$

(b) $9F2D_{16} = 1001\ 1111\ 0010\ 1101_2$

<u>32768</u>	<u>16384</u>	<u>8192</u>	<u>4096</u>	<u>2048</u>	<u>1024</u>	<u>512</u>	<u>256</u>	<u>128</u>	<u>64</u>	<u>32</u>	<u>16</u>	<u>8</u>	<u>4</u>	<u>2</u>	<u>1</u>
1	0	0	1	1	1	1	1	0	0	1	0	1	1	0	1

$$32768 + 4096 + 2048 + 1024 + 512 + 256 + 32 + 8 + 4 + 1 = 40,749_{10}$$

Addition of Binary Numbers

Example 0-8

Add the following binary numbers.

Solution:

	<i>Binary</i>	<i>Decimal</i>
	1101	13
+	<u>1001</u>	<u>9</u>
	10110	22

Table 0-3: Binary Addition

A + B	Carry	Sum
0 + 0	0	0
0 + 1	0	1
1 + 0	0	1
1 + 1	1	0

Example 0-9

Take the 2's complement of 10011101.

Solution:

	10011101	binary number
	01100010	1's complement
+	<u>1</u>	
	01100011	2's complement

ASCII Codes

American Standard Code for Information Interchange (ASCII)

$b_4b_3b_2b_1$	$b_7b_6b_5$							
	000	001	010	011	100	101	110	111
0000	NUL	DLE	SP	0	@	P	'	p
0001	SOH	DC1	!	1	A	Q	a	q
0010	STX	DC2	"	2	B	R	b	r
0011	ETX	DC3	#	3	C	S	c	s
0100	EOT	DC4	\$	4	D	T	d	t
0101	ENQ	NAK	%	5	E	U	e	u
0110	ACK	SYN	&	6	F	V	f	v
0111	BEL	ETB	'	7	G	W	g	w
1000	BS	CAN	(	8	H	X	h	x
1001	HT	EM	)	9	I	Y	i	y
1010	LF	SUB	*	:	J	Z	j	z
1011	VT	ESC	+	;	K	[	k	{
1100	FF	FS	,	<	L	\	l	!
1101	CR	GS	-	=	M	]	m	}
1110	SO	RS	.	>	N	^	n	~
1111	SI	US	/	?	O	-	o	DEL

Control characters

NUL	Null	DLE	Data-link escape
SOH	Start of heading	DC1	Device control 1
STX	Start of text	DC2	Device control 2
ETX	End of text	DC3	Device control 3
EOT	End of transmission	DC4	Device control 4
ENQ	Enquiry	NAK	Negative acknowledge
ACK	Acknowledge	SYN	Synchronous idle
BEL	Bell	ETB	End-of-transmission block
BS	Backspace	CAN	Cancel
HT	Horizontal tab	EM	End of medium
LF	Line feed	SUB	Substitute
VT	Vertical tab	ESC	Escape
FF	Form feed	FS	File separator
CR	Carriage return	GS	Group separator
SO	Shift out	RS	Record separator
SI	Shift in	US	Unit separator
SP	Space	DEL	Delete
